APPENDIX D:

CALCULATIONS RELATED TO CONTAMINANTS IN PARKING LOT STORMWATER RUNOFF

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Construction of the Center for Nanoscale Materials (CNM) facility would modify the surface configuration of the land southeast of the intersection of Kearney and Rock Roads at Argonne National Laboratory-East (ANL-E). This area is currently occupied by a detention area for surface runoff for 14.1 acres of land occupied by buildings, roads, parking areas and lawns. The construction of the CNM facility would modify the surface configuration of this area and add buildings, driveways, walkways, and parking areas. Driveways and walkways would be salted to protect workers and visitors during freezing conditions. Parking areas would collect automotive fluids and other contaminants from vehicles. When dissolved or lifted by precipitation, these salts and other contaminants could reach Wetland 302, which is downstream and directly across Rock Road from the proposed CNM site. Wetland 302 is a jurisdictional wetland and is maintained as mitigation for past, present, and future impacts to wetlands at ANL-E. To protect the wetland it is important to keep contaminants from entering the drainage system and affecting wetland vegetation. This appendix describes a series of calculations that were used to evaluate potential contaminants resulting from precipitation washing salts and other materials from walkways, roadways, and parking areas associated with the CNM and other areas in the Wetland 302 watershed.

D.1 AREAS

Three areas were examined in the evaluation of contaminant management (Table D.1). The largest area included the entire catchment area of Wetland 302. The smallest area included the proposed CNM site and portions of the APS ring and APS infield that currently drain into the retention area at the corner of Kearney and Rock Roads. From this retention area, drainage flows under Rock Roads to immediately combine with drainage from the southwest corner of the ANL-E site. This area west of Kearney Road is called the SW Catchment Area. Table D.1 includes the total surface area of these three catchment areas. The table also indicates the surface areas that are impervious to precipitation and are either salted (i.e., paved areas) or unsalted (i.e., building roofs). The table also indicates the area that is pervious, that is where precipitation is assumed to soak into the ground. It is assumed that 100% of precipitation runs off of impervious areas and into drainage ways. It is assumed that less than 100% of precipitation runs off of pervious surfaces and into drainage ways. The actual percentage that runs off of pervious surfaces depends on such factors as vegetation; soil type, compaction, and moisture; slope; and precipitation rate. For the analysis of salting and salt yield, it was assumed that no runoff occurred during snowmelt conditions in the winter and early spring. For an analysis of contaminant yields over various storm events, which may occur in the spring and summer, 30% runoff was assumed to represent an average value for the purposes of calculations of water yield.

TABLE D.1 Surface Areas of Land and Facilities within Wetland 302 Watershed

Area	Description	Existing Conditions (acres)[a]	CNM, North Parking (acres)[a]	CNM, North and South Parking (acres)[a]
Wetland 302: Catchment	Total	129.234	127.750	127.750
	Impervious area-salted	9.758	10.094	9.412
	Impervious area-unsalted	7.145	8.837	8.837
	Pervious area	112.331	108.819	109.501
CNM Drainage Area	Total	14.104	12.620	12.620
	Impervious area-salted	1.719	2.029	1.348
	Impervious area-unsalted	3.400	5.090	5.090
	Pervious Area	9.021	5.501	6.213
Wetland 302: SW Catchment	Total	32.925	32.925	32.925
	Impervious area-salted	0.316	0.316	0.316
	Impervious area-unsalted	0.010	0.010	0.010
	Pervious area	32.599	32.599	32.599

[a] 1 acre equals 43,560 ft^2, or 0.40469 hectare (ha).

D.2 SALT CONCENTRATIONS IN SITE RUNOFF

D.2.1 Introduction and Approach

This salt application analysis focuses on the CNM watershed, which discharges all of its runoff to Wetland 302 by means of a culvert under Rock Road, at the intersection of Rock and Kearney Roads. The CNM watershed includes salted roads (including a length of the south side of Rock Road and a length of the east side of Kearney Road), driveways, sidewalks, and parking lots (both current and proposed); building rooftops (both current and proposed); drainage from a portion of the center of APS conveyed by pipe under the APS building; and assorted pervious surfaces (both current and resulting from proposed construction), including lawns and road shoulders. The northern and northeastern portions of the CNM watershed drain into a ditch that flows west along Rock Road. Much of the rest of the watershed flows through ditches and culverts to reach the drainage basin currently at the southwest corner of the intersection of Kearney and Rock Roads. Here the flow joins the flow from the Rock Road ditch and enters a culvert under Rock Road to flow north into Wetland 302. On the north side of Rock Road, the culvert discharge is joined by flow from a culvert under Kearney Road that collects runoff from forested ANL-E property west of Kearney and from the ditch along the west side of Kearney. All of these ditches and culverts convey varying amounts of water, depending on the recent weather, and are likely either not flowing or totally dry for a large proportion of each year.

A geographic information system (GIS) analysis was used to determine the area of salted surfaces (roads, parking lots, sidewalks) (Table D.1). Gravel roads and other areas assumed to be unsalted and were ignored in the analysis. Salt was assumed to be spread uniformly over site roads and parking lots, although it is possible that some areas are salted heavier than others. Estimating the concentration of salt or chloride may follow a multitude of possible approaches. In this case, the estimation of the amount of salt loading from the CNM drainage basin was made using a lumped parameter approach, in which various sources of solute and solvent (water) are lumped together to determine an overall concentration at the watershed's outlet culvert.

The analysis needs to include a variety of different factors related to the salt application method, the amount of melted snow or rain available as runoff, and drainage and infiltration characteristics of a relevant watershed. This information can be combined to determine an estimated concentration at a given location and relevant to a particular time or time interval. Each salting event differs in terms of many factors, which may include:

- The salt application rate (mass/unit area),
- The number of salt applications if the snowstorm is prolonged,
- Amount of snowfall prior to plowing,
- Amount of snowfall following plowing and salting,
- Whether the individual plow driver plows the snow off a parking lot onto grass or into a pile in parking spaces,
- Whether surfaces are plowed at all or only salted,
- Temperature of pavement and ground,
- Type of snow or freezing rain,
- Timing of snowmelt and possible ground thaw, and
- Transient nature of salt dissolution and salt concentration in runoff from individual surfaces.

Because of these complicated factors, the winter season as a whole is considered in this analysis, rather than making estimates for individual salting events. In this manner, the season's salt application may be taken in total and be compared with the precipitation over the season. Data available over the season are more accurate than event-scale data for both salt usage and, especially, hydrologic factors such as precipitation and runoff.

Precipitation in DuPage County is 33.4 in. per year (USDA 1979). Of this annual average, 9.6 in. falls as snow, rain, or freezing rain during the winter salting season, assumed here to be November to March. A detailed rainfall-runoff analysis of the CNM watershed is beyond the scope of this analysis. Such a study would require a great deal of data, such as soil characteristics (structure, porosity, moisture content, frozen/thawed), vegetation mapping, precipitation assumptions (amount, intensity), and transient aspects of many of these factors. Instead, the approach followed considers that wintertime soil conditions may range from thawed (and allowing all water to infiltrate the pervious areas) to completely frozen (and allowing all water to run off the pervious areas). A bracketing approach is followed, in which the concentration at the CNM discharge outlet is calculated twice, once assuming that snowmelt completely soaks into the pervious portion of the CNM watershed (e.g., lawns, etc.) and contributes no runoff, and again assuming that pervious areas are frozen and all precipitation on the pervious areas runs off. While neither assumption yields “expected” values for runoff or infiltration proportions (during a season, both conditions may occur at different periods), they serve as a means of estimating the range of expected values in runoff. In turn they are used in estimating the range of values in chloride concentrations in watershed runoff. In each case, the impervious areas are assumed to contribute all their runoff to the outlet point.

D.2.2 Results

Annually, Argonne uses 800 to 1,000 tons of salt (Powell 2003). Assuming an average use of 900 tons, the average salt loading is 167,000 mg per ft^2 of salted pavement per year. Road salt is primarily sodium chloride. Chloride is the more critical ion in terms of environmental impact (TRB 1991). Salt is 60.7% chloride by weight. The seasonal salt loading was therefore converted from salt to chloride for use in calculating chloride concentrations.

Table D.2 presents the calculated chloride concentration in runoff from the CNM drainage area for the bounding assumption that the pervious ground remains frozen throughout the winter season, and the assumption that the pervious ground remains unfrozen during the winter season. This table includes the following scenarios:

- Current conditions: land contours and buildings remain without modification (no action).

- Alternative A: the CNM is constructed, land contoured, a 40,000-ft^2 parking lot is constructed north of the CNM, and a collection basin and pump are installed to remove the 90% of the salt and contaminates washed from the parking lot by melt water and precipitation. The pumped drainage would be sent out of the Wetland 302 watershed.

- Alternative B: the CNM is constructed, land contoured, and a 40,000-ft^2 parking lot is constructed with bioswales to remove other contaminants, but not chlorides.

- Alternative C: the CNM is constructed, land contoured, a 16,000-ft^2 parking lot is constructed north of the CNM, and a 37,000-ft^2 parking lot is constructed south of the CNM outside of the Wetland 302 watershed.

TABLE D.2 Estimated Concentration of Chloride in Runoff from the CNM Drainage Area and the Combined CNM and SW Drainage

Alternative[a]	Northward Drainage Area (ft^2)	Unsalted Impervious Area (ft^2)	Salted Impervious Area (ft^2)	Pervious Area (ft^2)	Chloride Application (mg/ft^2)	Chloride Loading (mg)	Water Yield, Frozen Pervious (L)	Water Yield, Thawed Pervious (L)	Chloride, Frozen Pervious (mg/L)	Chloride, Thawed Pervious (mg/L)
CNM Drainage										
Current	614,383	148,110	74,864	391,409	101,369	7.59×10^9	3.85×10^7	2.13×10^7	197	356
A	509,736	221,738	42,708	245,290	101,369	4.73×10^9	3.19×10^7	2.12×10^7	148	224
B	549,736	221,738	88,379	239,619	101,369	8.96×10^9	3.44×10^7	2.39×10^7	260	374
C	549,736	221,738	58,708	269,290	101,369	5.95×10^9	3.44×10^7	2.26×10^7	173	263
D	549,736	221,738	58,708	269,290	101,369	5.95×10^9	3.44×10^7	2.26×10^7	173	263
Combined SW[b] and CNM Drainage										
Current	2,048,576	148,566	88,649	1,811,361	101,369	8.99×10^9	1.28×10^8	4.89×10^7	70	184
A	1,943,929	222,194	56,493	1,665,242	101,369	6.13×10^9	1.22×10^8	4.88×10^7	50	126
B	1,983,929	222,194	102,164	1,659,571	101,369	1.04×10^{10}	1.24×10^8	5.15×10^7	83	201
C	1,983,929	222,194	72,493	1,689,242	101,369	7.35×10^9	1.24×10^8	5.02×10^7	59	146
D	1,983,929	222,194	72,493	1,689,242	101,369	7.35×10^9	1.24×10^8	5.02×10^7	59	146

[a] See text (Section D.2.2) for descriptions of alternatives.

[b] SW = southwest (meaning drainage of the southwest portion of the ANL-E site, see text of Section D.2.2).

- Alternative D: the CNM is constructed, land contoured, a 16,000-ft^2 parking lot is constructed north of the CNM, and a tiered parking structure is constructed south of the CNM outside of the Wetland 302 watershed.

A chloride level of 168 mg/L is the benchmark value developed for this EA for protection of wetland vegetation, as described in Chapter 4. At the assumed application rate of 167,000 mg/ft^2, the current conditions result in chloride concentrations from the CNM drainage area above this value for both frozen and thawed pervious ground. Current conditions and all alternative parking configurations also result in chloride concentrations above the benchmark value for when pervious ground is thawed. The only alternative that yields chloride concentrations below the benchmark value is A, the proposed action, in which parking lot drainage would be pumped south.

Drainage from the CNM area joins with drainage from the southwest portion of the ANL-E site prior to entering Wetland 302. Salt concentrations for the combined drainage are also shown in Table D.2. While chloride concentrations would be below benchmark values for all alternatives during frozen conditions, both the existing conditions and alternative B result in concentrations above benchmark values during thawed conditions. Under thawed conditions, the chloride concentrations are 69% of benchmark values for the proposed action (A) and 87% of benchmark values for alternatives where parking is constructed south of the CNM (C and D).

Various highway references were examined to gain an understanding of recommended salt usage on various roads in northern states and Canadian provinces. These suggest a range of 757 to 1,893 mg salt per ft^2 of highway per salting event. These values, however, represent highway application rates. The USGS (Heisig 1999) related state route salt application in New York State to highway application rates. The application on 4-lane highways exceeded the state route by a factor of two; interstates were higher by a factor of eight. It is reasonable to assume that the salt loading on Argonne roads and parking areas could be reduced below 167,000 mg/ft^2, thereby also providing wetland protection.

D.3 OTHER CONTAMINANTS

Parking lots gather other contaminants besides salt. These contaminants include oils, automotive fluids, rubber, and trace metals. It is generally assumed that the majority of contaminants are removed from the surface of paved areas during the “first flush” of runoff during precipitation events. Collection of this runoff would allow pumping of the water to the south out of the Wetland 302 watershed.

Precipitation events of short duration may be intense, as shown in Table D.3 which presents the gallons per minute that could be generated by rainfall on the CNM parking lot for different events of different durations and return periods, as listed in Huff and Angel (1989). In order to capture short-duration rainfall and the first flush of longer-duration rainfall, pumping would either be sized to the maximum runoff rate or a collection system would be used to allow

TABLE D.3 Potential Runoff Rate from the CNM Parking Lot

	Runoff Rate (gpm) by Return Period						
Duration	1-year	2-year	5-year	10-year	25-year	50-year	100-year
10-day	7	9	11	12	15	17	20
5-day	12	14	18	21	25	29	36
72-hour	18	21	27	33	40	46	53
48-hour	24	30	37	47	57	67	79
24-hour	45	55	69	81	99	117	137
18-hour	55	67	84	99	122	143	168
12-hour	79	95	120	140	173	203	238
6-hour	136	165	206	242	298	350	410
3-hour	231	280	351	413	510	598	701
2-hour	321	388	485	572	704	828	969
1-hour	511	620	776	910	1,122	1,317	1,543
30-minute	806	971	1,222	1,430	1,768	2,071	2,427
15-minute	1,179	1,421	1,785	2,097	2,583	3,033	3,553
10-minute	1,430	1,742	2,184	2,548	3,146	3,692	4,342
5-minute	1,560	1,872	2,444	2,808	3,432	4,056	4,732

smaller pumps to move the collected water over a longer period of time. For the proposed action, a collection basin would be used to collect the initial runoff from precipitation events to allow pumping of this water to the south out of the Wetland 302 watershed.

To compute the collection requirements for different events, a simple calculation was performed to determine the excess of runoff over pumping for storm durations of 5 minutes to 10 days for return periods of 1 to 100 years (Huff and Angel 1989). Table D.4 shows the retention capacity needed to completely contain the runoff from the CNM parking lot with a pumping rate of 80 gpm. Table D.5 presents the retention capacity needed to completely contain the runoff from the CNM parking lot with a pumping rate of 200 gpm. It was further assumed that contaminants collecting on the parking surfaces would be washed off the surface and be carried with the runoff during the first portion of the rain event. The assumption was that 90% of the contaminants would be washed off in the 0.5-in. of rainfall. In northern Illinois, this would be a 1-year, 10-minute event of 0.55 in.; a 2-year, 10-minute event of 0.57 in.; and a 5-year, 5-minute event of 0.47 in. (Huff and Angel 1989). With a 200-gpm pumping rate, the storage capacity needed for these events would be 11,750 gal, 14,750 gal, and 10,750 gal, respectively (Table D.5). Thus, for a 5-year return period, 0.5-in. rain events would be contained by a collection capacity of 14,750 gal, or 1,967 ft^3.

Further contaminant removal could be accomplished by collecting the first inch of rainfall. In northeastern Illinois, this would be a 1-year, 1-hour event of 1.18 in.; a 2-year, 30-minute event of 1.12 in.; and a 5-year, 15-minute event of 1.03 in. (Huff and Angel 1989).

TABLE D.4 Collection Capacity Required to Contain Runoff from the CNM Parking Area with Pumping Rate of 80 gpm

	Capacity (gal) Required by Return Period						
Duration	1-year	2-year	5-year	10-year	25-year	50-year	100-year
10-day	None	None	None	None	None	None	None
5-day	None	None	None	None	None	None	None
72-hour	None	None	None	None	None	None	None
48-hour	None	None	None	None	None	None	None
24-hour	None	None	None	None	22,550	46,300	74,300
18-hour	None	None	1,100	16,350	40,100	62,350	87,850
12-hour	None	8,400	25,150	39,650	62,150	82,900	107,150
6-hour	18,200	28,200	42,450	54,950	74,450	92,450	113,200
3-hour	25,600	34,100	46,350	57,100	73,850	89,100	106,850
2-hour	27,400	35,150	46,400	56,400	71,650	85,900	102,150
1-hour	24,700	30,950	39,950	47,700	59,950	71,200	84,200
30-minute	20,850	25,600	32,850	38,850	48,600	57,350	67,600
15-minute	15,800	19,300	24,550	29,050	36,050	42,550	50,050
10-minute	12,950	15,950	20,200	23,700	29,450	34,700	40,950
5-minute	7,100	8,600	11,350	13,100	16,100	19,100	22,350

TABLE D.5 Collection Capacity Required to Contain Runoff from the CNM Parking Area with Pumping Rate of 200 gpm

	Capacity (gal) Required by Return Period						
Duration	1-year	2-year	5-year	10-year	25-year	50-year	100-year
10-day	None	None	None	None	None	None	None
5-day	None	None	None	None	None	None	None
72-hour	None	None	None	None	None	None	None
48-hour	None	None	None	None	None	None	None
24-hour	None	None	None	None	None	None	None
18-hour	None	None	None	None	None	None	None
12-hour	None	None	None	None	None	None	20,750
6-hour	None	None	None	11,750	31,250	49,250	70,000
3-hour	4,000	12,500	24,750	35,500	52,250	67,500	85,250
2-hour	13,000	20,750	32,000	42,000	57,250	71,500	87,750
1-hour	17,500	23,750	32,750	40,500	52,750	64,000	77,000
30-minute	17,250	22,000	29,250	35,250	45,000	53,750	64,000
15-minute	14,000	17,500	22,750	27,250	34,250	40,750	48,250
10-minute	11,750	14,750	19,000	22,500	28,250	33,500	39,750
5-minute	6,500	8,000	10,750	12,500	15,500	18,500	21,750

With a 200-gpm pumping rate, the storage capacity needed for these events are 17,500 gal, 22,000 gal, and 22,750 gal, respectively. Thus, for a 5-year period, 1-in. rain events would be contained by a collection capacity of 22,750 gal, or 3,033 ft^3. Greater or lesser storage capacity would be needed for different pumping rates; 200 gpm was chosen for analysis to represent 50% of the output of a 400 gpm pump. A pump of this size is currently used at Argonne to pump runoff from a coal storage area.

D.4 REFERENCES FOR APPENDIX D

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